Geophysical Research Abstracts,
Vol. 11, EGU2009-1227, 2009
EGU General Assembly 2009

Organic matter protection as affected by the mineral soil matrix: allophanic vs. non-allophanic volcanic ash soils

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Volcanic ash soils (Andosols) contain the largest amounts of organic carbon of all mineral soil types. Chemical (complexes of organic matter with allophane, Al/Fe) and physical (aggregation) mechanisms are protecting the carbon from decomposition. While allophanic Andosols are dominated by short range order minerals such as allophane, imogolite and ferrihydrite, organic matter-Al/Fe complexes dominate non-allophanic Andosols. Consequently, chemical interactions between the mineral soil matrix and organic matter differ between these two soil types. This difference could potentially lead to different organic matter compositions. In this study, the organic matter of Ah horizons of an allophanic Andosol with a non-allophanic Andosol from Madeira Island is compared using analytical pyrolysis.

Both volcanic soil types showed a relative decrease of lignin-derived pyrolysis products with depth, but this decrease was more pronounced in the allophanic Andosol. Polysaccharides were more abundant in the allophanic Ah horizon, particularly at lower depth, and this was also the case for the non-plant-derived N-containing polysaccharide chitin. Most likely, these biopolymers are adsorbed onto short range order minerals such as allophane and therefore were better protected in the allophanic Andosol. In addition, the higher chitin contents combined with the more pronounced lignin degradation suggests a higher fungal activity. Aliphatic pyrolysis products (n-alkenes/n-alkanes, fatty acids) were relatively more enriched in the non-allophanic Andosol. Lower microbial activity caused by the more acidic pH and higher levels of (toxic) aluminium are the most plausible reasons for the accumulation of these compounds in the non-allophanic Andosol.

Although the allophanic and non-allophanic Andosol resembled each other in containing biopolymer groups of the same orders of magnitudes, in particular the contents of chitin and aliphatic compounds were distinctly affected by the differences in organic matter stabilizing properties and capacity of the mineral soil matrices.